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Utilisation of helicopter emergency medical services in the early medical response to major incidents: a systematic literature review

Anne Siri Johnsen,† Sabina Fattah,‡,§ Stephen J M Sollid,†,§ Marius Rehn†,∥

ABSTRACT

Objective: This systematic review identifies, describes and appraises the literature describing the utilisation of helicopter emergency medical services (HEMS) in the early medical response to major incidents.

Setting: Early prehospital phase of a major incident.

Design: Systematic literature review performed according to Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines.

Results: The database search identified 4948 articles. Based on the title and abstract, the full text of 96 articles was obtained; of these, 37 articles were included in the review, and an additional five were identified by searching the reference lists of the 37 articles. HEMS was used to transport medical and rescue personnel to the incident and to transport patients to the hospital, especially when the infrastructure was damaged. Insufficient air traffic control, weather conditions, inadequate landing sites and failing communication were described as challenging in some incidents.

Conclusions: HEMS was used mainly for patient treatment and to transport patients, personnel and equipment in the early medical management of major incidents, but the optimal utilisation of this specialised resource remains unclear. This review identified operational areas with improvement potential. A lack of systematic indexing, heterogeneous data reporting and weak methodological design, complicated the identification and comparison of incidents, and more systematic reporting is needed.

Trial registration number: CRD42013004473.

INTRODUCTION

Major incidents remain a major global health challenge. In 2013, natural-triggered disasters killed more than 20,000 people, created almost 100 million victims and caused enormous economic damage worldwide.1 These numbers are only for natural disasters and do not take into account other types of major incidents. Major incidents are characterised by the need for an extraordinary medical response. They are heterogeneous by nature and their unexpectedness remains a challenge for emergency medical services (EMS). Fundamental for an effective major incident response is a robust and resilient EMS system.2 These systems can provide rapid access to advanced major incident management to improve patient outcome3 and optimise resource allocation as demand often exceeds capacity.4

Helicopters are obvious resources in major incident management through their capacity to bring specialised teams and equipment to incident scenes. They can also transport patients, provide search and rescue services, and perform overhead surveillance. When a site is remote or difficult to access, helicopters may be the only way to transport personnel, equipment and patients in and out of it.5–9 Following the first organised use of helicopters for military medevac during the Korean War,10 the use of helicopters for civilian patient transportation was introduced in the USA in the early 1970s.11 It was later integrated as helicopter EMS (HEMS) in most high-income countries.12–14 Although HEMS is embedded in most emergency response plans, the optimal
use of this limited resource in the early medical management of major incidents remains unclear.

We aimed to systematically identify, describe, and appraise the literature that describes the utilisation of HEMS in the early medical response to major incidents, to better address common challenges and to facilitate future research.

**METHODS**

**Study identification**

The protocol was published prior to conducting the literature search, and registered in PROSPERO (CRD42013004473). A comprehensive literature search was performed to identify all relevant articles available as of 19 March 2015. The following databases were searched: MEDLINE, EMBASE, the Cochrane Central Register of Controlled Trials, the Web of Science, PsycINFO, Scopus, Cinahl, Bibsys Ask, Norart, Swemed and UpToDate. An additional search was performed in PubMed in order to retrieve articles that had not yet been entered into MEDLINE. The search was designed using Medical Subject Headings and related terms as keywords. This search was then adapted for use in the other databases (see online supplementary additional file I). In the absence of universally accepted nomenclature, literature that defined their incident as a major incident or disaster was included.

**Study eligibility and selection**

**Inclusion criteria:**

- Articles that describe the use of HEMS in the early medical management of a major incident.

**Exclusion criteria:**

- Articles in languages other than English and Scandinavian
- Articles without abstracts
- Book chapters, conference abstracts, letters to the editor and editorials

Deviations from the protocol on inclusion and exclusion criteria.

- Inclusion of commentaries
- Exclusion of literature where:
  - Only fixed-wing aircraft were used
  - Helicopters without dedicated medical capacity were used
  - Incidents were considered to be part of military conflicts
  - HEMS was used in the later recovery phase of the response.

The reason for the inclusion of commentaries was that these did not provide less relevant information than case reports. Exclusion criteria were adjusted to better target civilian medical helicopter response to major incidents in the acute phase.

**Search findings**

All studies were collected in an Endnote bibliographic database (2011; Thomson Reuters, USA). One author (ASJ) scanned the titles and abstracts, and excluded articles that clearly did not meet the inclusion criteria. Full-text versions of the remaining articles were obtained and divided among pairs of authors (ie, ASJ and MR, SF and SJMS) for further screening, using the criteria listed above. Excluded articles were listed with the reason(s) for exclusion. If there was any uncertainty about whether a study should be included, there was a discussion until a consensus was reached among all of the authors. The reference lists of the studies that were included initially were examined individually to identify the additional relevant literature.

**Data extraction and appraisal**

ASJ appraised the quality of the included studies and extracted predefined data from the included articles into an Excel spreadsheet (2010; Microsoft, USA). Data extraction included the demography of incident area and characteristics regarding HEMS, major incident, incident response and patient characteristics. The data extraction variables were pilot-tested on four randomly selected articles before the protocol was published.

The appraisal items were selected by the authors, and aimed to describe the internal and external validity of the included studies. All data extraction and appraisal results were agreed on by another co-author.

**RESULTS**

**Literature search**

The search identified 4948 records (2763 after duplicates were removed), and the full-text versions of 96 articles were obtained. Of these, 37 articles were included in the study, and an additional 48 were identified by searching through the reference lists of the 37 articles. Thus, the review included a total of 42 articles (table 1), with 59 articles excluded for various reasons (see online supplementary additional file II). The Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) diagram (figure 1) shows the inclusion and exclusion of articles in the different phases of this review.

**Data extraction**

None of the included articles contained all of the items on the data extraction list (figure 2). Basic information about the affected area was described in 12 articles (29%), information about the affected population in 24 (57%) and scene access in 29 articles (69%). Most papers described the characteristics of the incident. A timeline for the incident response was present in 25 articles (59%) and a description of personnel in 35 (85%) articles. In 12 (29%) of the articles, there was a lack of resources, prehospital surge capacity was reported in 2 (5%), and the response time was documented in 19 articles (45%). Communications and coordination were described in 34 articles (81%), and were in most cases failing. Scene safety was reported to...
Table 1 Study methods and use of HEMS

<table>
<thead>
<tr>
<th>Method</th>
<th>Described use of HEMS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Afzali et al</td>
<td>Brought extra equipment for advanced life support. HEMS doctor was Medical Incident Officer in three major incidents</td>
</tr>
<tr>
<td>Almersjø et al</td>
<td>Performed search and rescue and secondary transfers</td>
</tr>
<tr>
<td>Ammons et al</td>
<td>Evacuated the most severely injured patients to hospitals and brought extra equipment to the scene</td>
</tr>
<tr>
<td>Assa et al</td>
<td>Brought extra personnel and equipment to the scene. Air-medical crews assisted ground units in triage and treatment. Transportation of casualties from the remotely located scene to trauma centres. Allowed distribution of patients between various centres in the region</td>
</tr>
<tr>
<td>Bland</td>
<td>Command, triage, treatment and transport. Author was Forward Medical Incident Officer at Kings Cross scene</td>
</tr>
<tr>
<td>Bovender and Carey</td>
<td>Used for more than 200 helicopter sorties from flooded hospital</td>
</tr>
<tr>
<td>Brandsjø et al</td>
<td>Rescued main proportion of survivors, because nearby ships could not perform sea rescue</td>
</tr>
<tr>
<td>Brandstrom et al</td>
<td>Search and Rescue</td>
</tr>
<tr>
<td>Buerk et al</td>
<td>Evacuated severely injured patients. Caused disruption of radio communication and destroyed an aid station. The possibility of collision was a concern</td>
</tr>
<tr>
<td>Buhrer and Tilney</td>
<td>Patient transport with advanced life support and a secondary transfer to a burn centre</td>
</tr>
<tr>
<td>Carlasscio et al</td>
<td>Secondary transfers and rescued one patient. Brought extra crew and blood products</td>
</tr>
<tr>
<td>Cassuto and Tarnow</td>
<td>Secondary transfers from urban fire disaster</td>
</tr>
<tr>
<td>Cocanour et al</td>
<td>Evacuated patients from a flooded hospital. Used for longer distance transport</td>
</tr>
<tr>
<td>Eckstein and Cowen</td>
<td>Not clearly described</td>
</tr>
<tr>
<td>Felix Jr</td>
<td>Flew equipment to two damaged hospitals and transferred patients to other hospitals</td>
</tr>
<tr>
<td>Franklin et al</td>
<td>Patient transport from flooded areas to hospital and brought health personnel to places where they were needed</td>
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<tr>
<td>Furukawa</td>
<td>Transported personnel to the remote site of an airplane crash and airlifted survivors and dead from the scene</td>
</tr>
<tr>
<td>Iselius</td>
<td>Evacuation of injured passengers from railway accident. Brought extra crew and equipment to the site</td>
</tr>
<tr>
<td>Jacobs et al</td>
<td>Used for evacuation and transport of the most critically injured patients to trauma centres. Distributed them to different centres, so not to overwhelm the closest one</td>
</tr>
<tr>
<td>Lavery and Horan</td>
<td>Primary and secondary transport of injured patients</td>
</tr>
<tr>
<td>Lavon et al</td>
<td>Brought extra personnel, equipment and command team to the local hospital. Participated in secondary transfer with advanced trauma life support to larger trauma centre</td>
</tr>
<tr>
<td>Leiba et al</td>
<td>Brought extra personnel and blood products to the closest hospital and evacuated patients</td>
</tr>
</tbody>
</table>

Continued
be an issue in 18 reports (43%), and this was related to issues such as inadequate air traffic control, active shooters, inadequate landing sites and bad weather. HEMS tasks included patient evacuation and transport from scene as well as transport of supplies, personnel and equipment to the scene. The literature also described HEMS being used for secondary transport, treatment, leadership and on-scene triage. In addition, HEMS was

<table>
<thead>
<tr>
<th>Table 1 Continued</th>
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<tbody>
<tr>
<td>Method</td>
</tr>
<tr>
<td>------------------</td>
</tr>
<tr>
<td>Leiba et al⁴⁴</td>
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<tr>
<td>Lockey et al⁴⁵</td>
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<tr>
<td>Lyon and Sanders⁴⁶</td>
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<tr>
<td>Malik et al⁴⁷</td>
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<tr>
<td>Martchenke et al⁸⁸</td>
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<tr>
<td>Martin⁵¹</td>
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<tr>
<td>Matsumoto et al⁹⁹</td>
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<tr>
<td>Nates⁴⁰</td>
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<tr>
<td>Nia et al⁶³</td>
</tr>
<tr>
<td>Nicholas and Oberheide⁵²</td>
</tr>
<tr>
<td>Nocera and Dalton⁴¹</td>
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<tr>
<td>Oestern et al⁴²</td>
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<tr>
<td>Pokorny⁴³</td>
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<tr>
<td>Romundstad et al⁴⁴</td>
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<tr>
<td>Schwartz and Bar-Dayan⁴⁵</td>
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<tr>
<td>Sollid et al⁴⁶</td>
</tr>
<tr>
<td>Spano et al⁹</td>
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<tr>
<td>Stohler et al⁸</td>
</tr>
<tr>
<td>Urquieta and Varon⁴⁷</td>
</tr>
<tr>
<td>Yi-Szu et al⁹⁸</td>
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</tbody>
</table>
in some incidents utilised for search and rescue, and for air surveillance (table 1).

**Appraisal**

We sought to identify data items related to internal and external validity. Of the included articles, 19 (45%) contained references to where the data were obtained. We found 5 articles (12%) that reported no conflicts of interest and 1 (2%) that reported a conflict of interests. No articles reported they had ethical approval, although 1 (2%) stated that such approval was not needed. The description of both the HEMS and EMS structure before the incident was described in 12 (29%), whereas 7 articles (17%) described HEMS alone. The incident itself was clearly described in 40 articles (95%). Study limitations were discussed in 5 (12%), and the study design was described in 32 articles (76%). The quality appraisal findings are shown in figure 3. The study methodology was as follows: Of the 42 included studies, 37 (88%) were case reports, 2 (5%) observational studies, 2 (5%) reviews and 1 (2%) was a summary of the use of HEMS combined with a case report (table 1).

**DISCUSSION**

This systematic literature review found little or no systematic reporting of the utilisation of HEMS in the early medical management of major incidents. HEMS were most often reported to be used in patient evacuation and transport from the scene, and in transport of supplies and personnel to the incident scene (table 1). Data relevant to depict internal and external validity, such as reference to data source and handling of missing data, were lacking (figure 3). Further, the heterogeneity of the literature and the overall weak methodological design made it difficult to evaluate the contribution of HEMS to the management of major incidents.

The included incidents had various logistical and geographical challenges. In the 7/7 London terrorist bombings in 2005, a helicopter was used to deploy staff and equipment to urban scenes when road access was difficult. Use of a helicopter also allowed the deployment of staff from home at a time when public transportation was inaccessible in the city. In the 22/7 Utøya terrorist shootings in 2011, additional medical personnel were brought to the scene, which this time was a rural area with overloaded provincial roads. Other studies described how HEMS facilitated the transport of victims to the hospital, especially when the scene of the incident was difficult to access. HEMS also helped in secondary transfers of patients with particular needs, such as transporting patients to dedicated burns units. Although scene safety remains a foremost priority in major incident management, this was discussed in less than half of the studies. The inability to fly due to bad weather and the lack of designated landing sites were described as operational hazards. Further, HEMS involvement in major incident management often

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**Figure 1** Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA).
involved multiple aircraft operating in uncontrolled air space, indicating insufficient air traffic control.\textsuperscript{21} 23 27 38 46 Future improvements in aviation traffic awareness systems, navigation and communication may mitigate the aviation risks. However, the emphasis should be on implementing procedures for multiple aircraft operations in uncontrolled air space. Crew training may also reduce the

<table>
<thead>
<tr>
<th>DEMOGRAPHY</th>
<th>HEMS DESCRIPTION</th>
<th>INCIDENT CHARACTERISTICS</th>
<th>PATIENT CHARACTERISTIC DESCRIPTORS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Basic date of affected area</td>
<td>HEMS service area</td>
<td>Type of incident (heli-copter)</td>
<td>Other civilian (road, rail, or marine)</td>
</tr>
<tr>
<td>Basic information on affected population</td>
<td>Population involved by HEMS</td>
<td>Description of incident and the damage caused</td>
<td>Consequences (number deceased, injured)</td>
</tr>
<tr>
<td>Accessibility in the region</td>
<td>Population covered by HEMS</td>
<td>Description of incident and the damage caused</td>
<td>Consequences (number deceased, injured)</td>
</tr>
<tr>
<td>Other relevant non-incident information</td>
<td>Population covered by HEMS</td>
<td>Description of incident and the damage caused</td>
<td>Consequences (number deceased, injured)</td>
</tr>
<tr>
<td>Population covered by HEMS</td>
<td>Population covered by HEMS</td>
<td>Description of incident and the damage caused</td>
<td>Consequences (number deceased, injured)</td>
</tr>
<tr>
<td>Type of operation in the region</td>
<td>Population covered by HEMS</td>
<td>Description of incident and the damage caused</td>
<td>Consequences (number deceased, injured)</td>
</tr>
<tr>
<td>Operating hours</td>
<td>Population covered by HEMS</td>
<td>Description of incident and the damage caused</td>
<td>Consequences (number deceased, injured)</td>
</tr>
<tr>
<td>Previous experience with major incidents</td>
<td>Population covered by HEMS</td>
<td>Description of incident and the damage caused</td>
<td>Consequences (number deceased, injured)</td>
</tr>
<tr>
<td>Time, date and place of major incident</td>
<td>Population covered by HEMS</td>
<td>Description of incident and the damage caused</td>
<td>Consequences (number deceased, injured)</td>
</tr>
<tr>
<td>Total number of victims involved</td>
<td>Population covered by HEMS</td>
<td>Description of incident and the damage caused</td>
<td>Consequences (number deceased, injured)</td>
</tr>
<tr>
<td>Scene access</td>
<td>Population covered by HEMS</td>
<td>Description of incident and the damage caused</td>
<td>Consequences (number deceased, injured)</td>
</tr>
<tr>
<td>Division to hospital</td>
<td>Population covered by HEMS</td>
<td>Description of incident and the damage caused</td>
<td>Consequences (number deceased, injured)</td>
</tr>
<tr>
<td>Other incident characteristics</td>
<td>Population covered by HEMS</td>
<td>Description of incident and the damage caused</td>
<td>Consequences (number deceased, injured)</td>
</tr>
<tr>
<td>Other patient characteristics</td>
<td>Population covered by HEMS</td>
<td>Description of incident and the damage caused</td>
<td>Consequences (number deceased, injured)</td>
</tr>
</tbody>
</table>

Figure 2 Data extraction.
risks associated with confined area landings and bad weather flight operations.

The heterogeneous nature of major incidents is reflected by the lack of a common nomenclature. Several definitions of a major incident have been proposed that differ slightly from each other. To avoid excluding relevant articles, literature that defined their incident as a major incident or disaster was included.
Our findings emphasise that a universally accepted definition of major incident is needed to facilitate comparative studies and to improve the accuracy of database indexing.

Our appraisal found that the majority of the included articles provided detailed descriptions of the incidents but that there was a tendency towards inadequate descriptions of the everyday HEMS system. The lack of...
baseline data made it difficult to evaluate the deployment and utilisation of extraordinary resources during major incidents. The methodological designs were generally weak and dominated by retrospective observational case reports. This is not surprising considering the difficulties in planning and executing prospective studies on major incidents. With an established template of standardised variables, a prospective study design can, however, be established to collect data from major incidents. If similar data are collected from major incident exercises in similar systems, a case–control design can even be applied to future studies. Such studies can be further strengthened by including other data sources such as focus group interviews from involved personnel in the sense of method triangulation.\(^\text{50}\)\(^\text{60}\) We also found that some incidents were described by several reports, indicating possible skewness in the literature regarding high-profile incidents. As with all unstructured reporting, establishing a denominator for HEMS involvement proved difficult, again highlighting that future research should build on systematically collected data with uniform variable definitions to allow better comparisons.\(^\text{61}\)

**Limitations**

The authors selected items for use in data extraction and appraisal that they assumed were relevant. However, these items do not represent a reference standard, since such a standard does not exist, to our knowledge.

Many major incidents occur in non-English-speaking countries; accordingly, it is a weakness that only articles in English and the Nordic languages were included. However, the included articles described incidents on different continents, which improve the generalisability of the findings. Further, we may have failed to identify some relevant studies, since articles without abstracts were not included, and a single author performed the initial screening.

**Conclusion**

This systematic literature review identified, described and appraised the literature on the utilisation of HEMS in the early medical management of major incidents. Heterogeneous data reporting complicated our efforts to identify and evaluate the overall utilisation of HEMS in such incidents. To address such shortcomings, systematic uniform reporting of HEMS in major incidents is called for.

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**Contributors**

ASJ and MR conceived the study. ASJ, MR, SJMS and SF took part in study design, data analysis and writing of the manuscript, and approved the final version of the manuscript.

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**Competing interests**

None declared.

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**Data sharing statement**

No additional data are available.

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